

1 TITLE OF THE INVENTION

2 Compliant Workholder for Machinery

3 INVENTORS

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5 CROSS-REFERENCE TO RELATED APPLICATIONS

6 This application is a continuation-in-part of Application No. 10/058,471, filed 1/28/2002.

7 STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

8 Not Applicable

## BACKGROUND OF THE INVENTION

### **Field of the invention**

The present invention relates to the field of workholders or hold downs for machinery and specifically to such workholders which act to urge a workpiece, such as a board, against a fence or other guide.

### **Background Information**

There are a wide variety of applications in which a substantially linear workpiece is fed into or through a machine which performs some operation on the workpiece. In carrying out this operation, it is common to use a fence, or other guide, to properly align the workpiece. A simple example is ripping a board on table saw. In order for the fence to be effective, the workpiece must be held tightly against the fence. While this may be done by hand, safety, accuracy, and productivity concerns often dictate the use of a workholder.

These workholders may be rollers, springs, featherboards, or any of a variety of similar devices. Their operation is relatively straight forward. A feather board for example is attached to the table of the machine, adjusted so that it contacts the edge of the board at the correct angle and with the desired pressure, and then locked down. Common to most of these workholders is that they must be adjusted to the width of the workpiece and reset if that width changes or another workpiece is substituted. While they can accommodate a small amount of variation in the width of the workpiece, such as an inch or so, they are not intended to accommodate large variation.

This is troublesome in several circumstances. The first is where the edge of the board being contacted by the workholder is irregular. This is common in rough cut lumber for example. The edge may be wavy, varying 2 or 3 inches (or more) along the length of the board. A conventional workholder which is set properly for the narrowest portion, will jamb at the widest portion. If set for the widest portion, it will lose contact with the narrowest portion, failing to

1 perform its function. Even where the variation is within limits, wide variations in pressure on the  
2 workpiece may result, affecting feed rates and finish quality of the operation. A second  
3 circumstance is where the board tapers, perhaps by design. This is similar to the above, but  
4 may have a significantly greater range of width which must be accommodated. A third  
5 circumstance is where a series of strips is being removed from the fence side of the workpiece.  
6 At each pass, the workpiece becomes narrower, requiring the workholder be reset as often as  
7 each pass.

8         The last situation, above, can be addressed with conventional workholders, but can  
9 seriously impact the productivity, and enjoyment, of the operation. The first two situations can  
10 not be handled by conventional workholders, and performing the operation without the  
11 workholders may pose a serious safety risk by requiring hand guiding.

12         The above situations may also involve dimensional variation in more than one direction.  
13 The simplest is where the workpiece varies in both width and thickness, and the operation  
14 requires that the workpiece be held both horizontally against a fence and vertically against the  
15 table. Other circumstances may require other orientations of the second workholder.

16         There is a need for a workholder for use with machinery which can accommodate  
17 relatively wide variations in the width of the workpiece, or variations in the contour of the edge  
18 which it contacts. It should also readily adapt to width variations between workpieces without  
19 requiring manual repositioning. It should maintain a relatively constant pressure against the  
20 workpiece despite these variations. Ideally its operation would require minimal intervention by  
21 the operator and be adaptable to circumstances or operator preferences. Also ideally, it would  
22 also allow for at least two separate workholders, commonly controlled for applying force in two  
23 or more directions.

## BRIEF SUMMARY OF THE INVENTION

The present invention is directed to a system of two or more compliant workholders for use with a piece of machinery, the workholders preferably using one or more pneumatic pistons to press a feather board or other contact element against the workpiece with substantially constant pressure. The pistons(s) allow the contact element to move in and out, following the edge of the workpiece as its profile varies.

According to the invention each of the workholder is provided with a frame which is mounted to the piece of machinery, a guide rod which slides in the frame, a head mounted on the outer end of the rod, and a mechanism for pushing the head outward against the workpiece.

According to an aspect of the invention the head will mount a resilient contact element, such as a feather board to make contact with the workpiece.

According to another aspect of the invention the head is retracted when the user presses a switch and remains retracted for a user selectable period of time.

According to yet another aspect of the invention, the timing of the workholders is individually adjustable, and either may be set to extend before the other.

The advantages of such an apparatus are that the head maintains substantially constant pressure against the workpiece while extending and retracting to follow the contour of the workpiece. The resilient contact element, such as a feather board, adapts to more minor irregularities. The easy retraction simplifies insertion of the workpiece, eases user operation, and increases the likelihood that the workholder will be used. Workpiece to workpiece variations are also accommodated as the head will extend until the workpiece is contacted, or the movement limits reached.

The above and other features and advantages of the present invention will become more clear from the detailed description of a specific illustrative embodiment thereof, presented below in conjunction with the accompanying drawings.

1 BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

2 FIG. 1 is an isometric view of the preferred embodiment of the present invention, with  
3 the air hoses removed for clarity.

4 FIG. 2 is a top view of the preferred embodiment of the present invention, with the air  
5 hoses removed.

6 FIG. 3 is a diagram of the pneumatic components of the invention and their  
7 interconnecting air hoses or lines.

8 FIG. 4 is an isometric view of the inventive workholder installed on a representative  
9 machine, a table saw.

10 FIG. 5, is a top view of the inventive workholder installed on a table saw.

11 FIG. 6 illustrates the workholder, installed on a table saw, in its fully retracted position  
12 allowing placement of the workpiece.

13 FIG. 7 illustrates the workholder, installed on a table saw, extended against the  
14 workpiece at a narrow section.

15 FIG. 8 illustrates the workholder, installed on a table saw, extended against the  
16 workpiece, but partially retracted, or compressed, to accommodate a wide section of the  
17 workpiece.

18 FIG. 9 is an isometric view of an alternative embodiment of the present invention with its  
19 cover in place.

20 FIG. 10 is an isometric view of the alternative embodiment of FIG. 9 of the present  
21 invention with the cover exploded to reveal the internal components.

22 FIG. 11 is a top view of the alternative embodiment of FIG. 9 with the cover removed.

23 FIG. 12 is a diagram of the components of a system having two workholders, with  
24 common controls.

1            FIG. 13 is an isometric view illustrating the components of FIG. 12 arranged to provide  
2   horizontal and vertical workpiece holding.

## DETAILED DESCRIPTION OF THE INVENTION

The following discussion focuses on the preferred embodiment of the invention, as a compliant feather board for a table saw. However, as will be recognized by those skilled in the art, the disclosed method and apparatus are applicable to a wide variety of situations in which it is desired to hold a possibly varying size workpiece against a fence or quite with constant pressure.

### **Glossary**

The following is a brief glossary of terms used herein. The supplied definitions are applicable throughout this specification and the claims unless the term is clearly used in another manner.

Cutter – the element of the machine to which the invention is attached which cuts, shapes, or otherwise acts on the workpiece.

Featherboard – that portion of the invention in direct contact with the workpiece. Generally similar to a conventional featherboard, but could encompass a leaf spring, roller, or slide arrangement.

Fence – a guide, typically perpendicular to the table which guides the workpiece into or through the cutter.

Table – generally that surface of the machine to which the invention is attached which supports the workpiece.

Workpiece – a piece of stock or material which is fed through the machine to which the invention is attached and which the invention acts upon.

### **Preferred Embodiment**

The disclosed invention is described below with reference to the accompanying figures in which like reference numbers designate like parts. Generally, numbers in the 200's refer to

1 prior art elements or elements in the surrounding environment while numbers in the 100's refer  
2 to elements of the invention.

### 3 **Overview**

4 The present invention is a pneumatically operated compliant workholder, 100, for  
5 attachment to the table, 202, of a stationary woodworking machine, 200, or similar device, to  
6 hold a workpiece against the fence, 204, or other guide, as the workpiece is fed through or into  
7 a cutter, 206. See FIGs. 4 and 5. While the original embodiment was developed for use with a  
8 table saw, the inventive device is clearly usable with a wide variety of other woodworking tools  
9 such as shapers and joiners and with machinery used for working metal, plastic, or other  
10 materials. Its potential applicability is as broad as any application requiring a workpiece to be  
11 urged against a guide while being fed through a machine which operates on the workpiece.

12 The novelty of the invention lies in its ability to tolerate large dimensional variation in the  
13 workpiece while maintaining a substantially constant pressure. In the preferred embodiment,  
14 the individual fingers of the featherboard follow the edges of the workpiece and accommodate  
15 small variations in the edge contour. Larger variations are accommodated by the pneumatic  
16 piston(s) which urge the head, on which the featherboard is mounted, toward the workpiece.  
17 Each piston is free to move in and out, maintaining substantially constant pressure throughout  
18 the range of motion of the piston.

19 While the preferred embodiment utilizes pneumatically activated pistons, other options  
20 are anticipated. Other fluid power systems would also work such as a hydraulic system which  
21 has been adapted to maintain constant pressure against the workpiece while allowing  
22 movement of the head. Active control of positive control elements such as stepper motors  
23 and/or linear activators could also be used in place of the pistons, but suffer significant  
24 disadvantages in terms of complexity and cost.

## Structure

Referring to FIGs. 1 and 2, the structure of the inventive workholder can be seen in more detail. Note that the required lines, or tubes, interconnecting the various pneumatic components have been removed for clarity. They are shown diagrammatically in FIG. 3. The frame, 102, provides attachment points and structural support for the other components. It also mounts to the table of the machine on which the device is installed via holes, 122, for mounting bolts or through the use of clamps. Featherboard, 108, mounts to head, 106, which in turn mounts to guide rods, 110, allowing the head to slide in and out relative to the end of the frame. The dual rod configuration of this embodiment provides a solid mount for the head while allowing linear motion in only one dimension and eliminating all rotational motion. This substantially eliminates all lateral and angular stress on the piston, decreasing wear on the piston.

The featherboard, 108, is the preferred mechanism for making contact with the workpiece. Each finger flexes individually, providing resilient contact with the workpiece. The angle of the fingers provides a measure of kickback protection by digging into or gripping the workpiece if it attempts to reverse direction. In the preferred embodiment, the featherboard is comprised of two or more identical sections which are stacked vertically, as shown. Additional sections can be added if desired or only one section may be used. This adapts the device to varying workpiece thicknesses and to the clearance requirements of different machines. This multiple section configuration can also reduce replacement cost as the featherboard wears and must be replaced as only those sections actually exhibiting wear need be replaced. The configuration also improves the functionality of the featherboard by increasing the number of separate fingers in the featherboard. Two vertically adjacent fingers can react separately to different contours in the workpiece which exist at different heights. Clearly a single, unitary

1 featherboard could also be used if preferred. Also, the featherboard and head could be integral  
2 if preferred.

3 The head, 106, and featherboard, 108, are urged outward against the workpiece by the  
4 action of the double acting piston, 120, which also serves to retract the head and featherboard.  
5 Note that the piston could also attach to the rod rather than directly to the head. Air flow to the  
6 piston, and thus the action of the piston, is controlled by valve, 112, which is itself pneumatically  
7 controlled by activation switches, 104. Bleed valve, 118, cooperates with the activation  
8 switches to provide a time delay for extension of the piston. The details of the controls and  
9 piston activation are discussed in detail below with reference to FIG. 3. Coupling, 116, provides  
10 a connection to a source of compressed air which may be conventional shop air. Pressure  
11 relief, 114, prevents the occurrence of an overpressure condition within the device and is not  
12 required for effective operation of the device. An optional cover may be provided as illustrated  
13 with the alternative embodiment discussed below.

14 The preferred configuration of the pneumatic components is illustrated in FIG. 3. Note  
15 that the following description refers to a single activation switch, 104. The preferred  
16 embodiment uses a second activation switch, 104', and additional switches can be added in  
17 parallel as desired. If desired, one or more of these activation switches may be located remote  
18 from the device, attached to the machine, carried by the operator, or in any other location as  
19 long as they are connected as illustrated. Clearly other types of remote activation could also be  
20 provide, such as radio frequency, or infrared as long as the same functionality is provided.

21 Connection, 116, provides an air supply at a constant, regulated pressure. Preferably,  
22 this pressure can be adjusted by the operator to regulate the holding pressure of the inventive  
23 device. If desired, this pressure regulator could be integrated into the device itself. Line, 130,  
24 conveys this supply air to inlet port, 140, of the valve, 112, and inlet port, 154, of activation  
25 switch, 104. The valve has two positions. In its relaxed state, where no air pressure is applied

1 to its control port, 146, the valve couples its inlet port, 140, to outlet port, 142. Tube 132,  
2 connects port 142 to port, 156, of the piston, 120, causing it to extend rod, 124, which then  
3 extends the featherboard. The result of this is that the normal, steady state condition of the  
4 device is that pressure is maintained to extend the piston.

5 Activation switch, 104, is a two position momentary switch with its outlet port, 148,  
6 connected to the control port, 146, of the valve, 112, via line 136. Inlet port, 154, is connected  
7 to the supply air and inlet port, 150, is connected to bleed valve, 118. In its normal, relaxed  
8 state, the activation switch couples outlet port, 148, to inlet port, 150. This connects the bleed  
9 valve, 118, to the control port, 146, of the valve, assuring that the control port will eventually  
10 return to atmospheric pressure (unless the bleed valve is fully closed).

11 When button, 152, is depressed, inlet port, 154, is momentarily coupled to outlet port,  
12 148. This applies pressure to the control port, 146, of the valve, causing the valve to activate.  
13 When activated, the valve vents outlet port, 142, and couples inlet port, 140, to outlet port, 144,  
14 supplying pressure to port, 158, of the piston, causing it to retract. The piston will remain  
15 retracted as long as pressure is maintained above a certain, device dependent, threshold level  
16 on the control port, 146 of the valve. When button, 152, is released, it will return under spring  
17 pressure to its relaxed state, again coupling the bleed valve, 118, to the control port, 146, of the  
18 valve. The bleed valve is, preferably, an adjustable needle valve which controls the escape of  
19 the air pressure which has been applied to the control port. The rate of this escape effectively  
20 controls a time delay from when the button is released until the valve is released and the piston  
21 extends. In the preferred embodiment, this can be easily varied in a continuous range from  
22 almost instantaneous to a minute or more. Once the valve, 112, is released, the piston extends  
23 under full supply pressure.

24 Clearly other schemes could be easily adopted including one in which the rate of  
25 extension could be regulated, either separately from, or in combination with the above time

1 delay. A simple approach to this is to use a spring to urge the piston (and featherboard)  
2 outward, rather than air pressure, and to couple a bleed valve to the retraction port, 158. The  
3 air pressure must then overcome the spring pressure in order to retract the piston and the bleed  
4 valve will gradually release this pressure allowing the piston to extend at a regulated rate.  
5 Another approach is to supplement the configuration of the preferred embodiment with a needle  
6 valve and bypass on line, 132, so that the rate at which supply air is provided to extend the  
7 piston is regulated, but it is allowed to vent unrestricted. Clearly, paired single acting pistons  
8 could also be used in place of a double acting piston. Herein, the disclosed double acting  
9 piston is intended to be considered as comprising two separate means: one for extension and one  
10 for retraction.

#### 11 **Extended System**

12 FIG. 12 illustrates the components of an extended system providing a second piston,  
13 172, which provides workholding in a second direction. The basic control scheme for the  
14 second piston is analogous to that for the first, with valve, 174, controlling the second piston in  
15 the same manner as valve, 112, does the first, and needle valve, 176, acting as a bleed valve,  
16 controlling the delay period until the piston extends, in the same manner as needle valve, 118,  
17 does for the first piston.

18 Valve, 178, performs the much the same function as switch 104, alternately connecting  
19 valve, 174, to either line pressure or to needle valve, 176. It operates under control of switch  
20 104. In a simpler alternate configuration, valve 178 could be eliminated and pistons 172 and  
21 124 would be synchronized.

22 However, the inclusion of valve 178 enables significant functional capability, beyond  
23 what might be expected. First, it allows a separate bleed valve, 176, to control the extension  
24 timing of piston 172. Thus, piston 120 and 172 can be retracted at the same time, but adjusted  
25 to extend at different times.

1 In the simple arrangement, valves 178 and 112 operate at the same pressure, and their  
2 control ports are coupled by line, 186. In this configuration, valves 178 and 112 will operate  
3 substantially simultaneously and the system can be adjusted so that the timing of the extension  
4 of piston 172 can vary from being substantially simultaneous with piston, 112, to significantly  
5 delayed after that time. This is achieved by adjusting needle valve, 176, to vary the rate at  
6 which bleed air is released. As with valve 112, described above, valve 174 will release when  
7 the supply pressure, being bled by needle valve, 176, drops below its operating pressure. With  
8 valve, 176, wide open, this is almost instantaneous with the release of valve 178. With reduced  
9 settings of valve, 176, this is delayed. However, with valves, 112 and 178, having the same  
10 operating pressure, piston, 172, can not be extended before piston, 120.

11 Greater flexibility is achieved in the preferred embodiment by using a valve, 178, which  
12 operates at a higher pressure than valve, 112. As long as the supply pressure to the system is  
13 greater than both operating pressures, valve 112 and 178, both activate immediately after  
14 button switch, 104, is depressed. When the switch is released, it connects line 136, and line  
15 186, to needle valve, 118. If valve, 118, is at least slightly open, it begins releasing pressure  
16 from the line, which is coupled to both of valves 112 and 178. As this pressure drops, it will first  
17 reach the higher operating pressure of valve, 178, causing it to release before valve, 112. The  
18 pressure will continue to drop, eventually reaching the operating pressure of valve, 112, causing  
19 it to release. Thus, valve 178 will always release before valve 112. Bleed valve, 118, can be  
20 adjusted, altering both the time to the release of valve, 178, and the subsequent delay until the  
21 release of valve 112.

22 Because valve, 178, is not connected directly to piston, 172, its release does not  
23 necessarily cause the piston to extend. This is because of valve, 174. When switch, 104, is  
24 pressed it supplies service pressure to valve, 178, which in turn supplies service pressure to  
25 valve, 174. However, when valve, 178, releases, it does not simply release the service

1 pressure to valve, 174. Instead, it couples line, 188, to needle valve, 176, which also acts as a  
2 bleed valve, releasing the line pressure at a controlled rate. This effectively delays the release  
3 of valve, 174, for a controllable period after the release of valve, 178. With valve, 176, wide  
4 open, the two valves operate substantially simultaneously. Because valve, 178, releases before  
5 valve, 112, this means that valve, 174, also releases before valve, 112, and thus piston, 172,  
6 will extend before piston, 120. However, if bleed valve, 176, is adjusted to slow the release of  
7 line pressure, the release of valve, 174, is correspondingly delayed. This delay period can be  
8 made longer than the difference between the release of valve, 178, and valve, 112, with the  
9 result that valve, 174, will release later than valve, 112, and so piston, 172, will extend later than  
10 piston, 120. Thus, by adjusting the relative settings of bleed valves, 118 and 176, the system  
11 can be set so that either of the pistons will extend first. With needle valves capable of  
12 sufficiently fine adjustment, the range of time delays which can be achieved is quite broad, from  
13 almost instantaneous to a minute or more.

14 Clearly, other configurations could be used to also achieve these results, but the  
15 preferred embodiment offers surprising flexibility with a minimal number of very reliable parts.

16 This ability to adjust the system so that either piston extends first offers significant  
17 advantage in material handling. It allows, for example, a board to be first urged against a fence  
18 and then downward against the table, in sequence. Or, by reversing the sequencing, the same  
19 system will first press the material against the table, and then against the fence.

20 FIG. 13 illustrates one possible configuration of the above extended system in which  
21 workholder, 100, operates horizontally as above, while workholder, 190, operates vertically. As  
22 discussed above, the present invention is not limited to use with a horizontal and vertical  
23 workholder. It is clearly also applicable to two workholders operating in the same plane, as for  
24 two locations along a fence, including an infeed and an outfeed location.

## 25 **Operation**

1           The operation of and individual inventive workholder is illustrated in FIGs. 6 – 8 where a  
2 board, 210, is being cut on a table saw, 200, fitted with the workholder, 100. At the start of the  
3 operation the head is retracted and the board positioned ahead of the blade, FIG. 6. After the  
4 time delay regulated by the bleed valve, the workholder extends until the featherboard, 108,  
5 contacts the board and the board is urged against the fence, 204. At this point, the cut can be  
6 started, FIG. 7. As the board is fed through the saw, the fingers of the featherboard will flex to  
7 follow small irregularities in the edge of the board. Larger variation in the board are  
8 accommodated by movement of the head. As shown in FIG. 8, as the edge of the board moves  
9 towards the workholder, the head is allowed to retract, maintaining constant pressure on the  
10 board and providing clearance for it to pass through the machine. As the board narrows, the  
11 head will again extend.

12           The use of a featherboard also helps overcome a potential problem with the piston often  
13 referred to as “stiction.” While the piston has minimal frictional resistance to movement while in  
14 motion, when stationary it may require a measurably larger force to start it in motion. This could  
15 cause an undesirable increase in pressure against the workpiece until movement starts. The  
16 flexing of the featherboard helps offset this, resulting in smoother application of force to the  
17 workpiece.

18           The adjustable time delay allows the device to be readily adapted to different modes of  
19 operation. Where a relatively small workpiece is being handled, the delay period can be set  
20 very short, or non-existent. In this mode, the operator can depress and hold the activation  
21 switch, place the workpiece in position, and then release the switch. The workholder will  
22 immediately extend, contacting the workpiece. Where a larger workpiece is being handled the  
23 delay period can be set longer. This would allow the operator to depress the activation switch,  
24 causing the workholder to retract, step back, pick up the workpiece and position it on the  
25 machine, and then wait for the workholder to automatically extend. As discussed above, the

1 activation switches can also be mounted remote from the frame of the device. It is also possible  
2 for the operator to use the end of the workpiece itself to activate the switch.

3 The extended system is operated in a similar manner. The button switches operate both  
4 pistons. Their relative timing is adjusted by altering the relative bleed rates of the two needle  
5 valves, 118 and 176, as described above.

6 In a conventional installation, the inventive workholder will be connected to a shop air  
7 supply comprising compressor, tank, and pipes or hoses. The combination of tank and pipes  
8 acts as an air reservoir having capacity significantly larger than the piston of the workholder.  
9 Thus, when the piston is forced to retract by a change in the contour of the board, the amount of  
10 air displaced from the piston is insignificant relative to the capacity of the entire system, so there  
11 is no appreciable pressure change. This is also true where extension of the piston consumes  
12 air. Where the air supply system has a smaller, or possibly no storage capacity, the invention  
13 could be supplemented by a reservoir or pressure relief valve to maintain a constant pressure.

#### 14 **Alternative Embodiments**

15 The following discussion presents alternative embodiments which offer various  
16 advantages in structure or functions without departing from the principles of the invention.

17 FIGs. 9 – 11 illustrate an alternative dual piston embodiment of the invention. Its control  
18 and general operation is the same as the preferred embodiment, above. It differs in that the  
19 head is free to pivot on the single guide rod, 164. Two pistons, 160, connect to the head and  
20 cause it to extend and retract. Since the pistons are interconnected, they are maintained at a  
21 common pressure and thus the ends of the head maintain a uniform force. This results in the  
22 head angling to follow the edge contour of the workpiece. Preferably, the piston rods are  
23 coupled to the head using pins which ride in slots, 166, allowing the head to angle without  
24 requiring a lateral displacement of the cylinder rods. Alternatively, another arrangement, such  
25 as pivoting the cylinders at their attachment to the frame, could be used. Similar, but inferior,

1 results could be achieved by using a single piston, no guide rods, and allowing the head to pivot  
2 freely on the end of the piston rod. This configuration could be expected to exhibit increased  
3 cylinder wear and less uniform pressure on the workpiece.

4 The embodiment of FIGs. 6 – 8 also utilizes a modified frame, 102', which incorporates  
5 additional mounting holes, 168, and which has been adapted to accept a cover, 170. The  
6 location and mounting of some of the pneumatic components has been altered to accommodate  
7 the cover.

8 While the featherboard offers certain advantages in adjusting to small variations in the  
9 workpiece, it is not essential to the present invention. It could be replaced as a workpiece  
10 contact by one or more rollers; a leaf spring arrangement; a low drag skid (such as UHDPE  
11 plastic) optionally backed by a resilient layer such as high density foam rubber; or any other of a  
12 variety of contact means. These contact elements could be made interchangeable to allow the  
13 operator to adapt the workholder to the specific type of workpiece being handled.

14 While the preferred form of the invention has been disclosed above, alternative methods  
15 of practicing the invention are readily apparent to the skilled practitioner. The above description  
16 of the preferred embodiment is intended to be illustrative only and not to limit the scope of the  
17 invention.